OCCUPATIONAL SAFETY AND HEALTH GUIDELINE FOR CYANOGEN

INTRODUCTION

This guideline summarizes pertinent information about cyanogen for workers and employers as well as for physicians, industrial hygienists, and other occupational safety and health professionals who may need such information to conduct effective occupational safety and health programs. Recommendations may be superseded by new developments in these fields; readers are therefore advised to regard these recommendations as general guidelines and to determine periodically whether new information is available.

SUBSTANCE IDENTIFICATION

- **Formula**

  $(CN)_2$

- **Synonyms**

  Carbon nitride, dicyan, dicyanogen, ethane dinitrile, nitriloacetonitrile, oxalic acid dinitrile, oxalic nitrile, oxalonitrile, oxalyl cyanide, prussite

- Identifiers

  1. CAS No.: 460-19-5
  2. RTECS No.: GT1925000
  3. DOT UN: 1026 18
  4. DOT label: Poison Gas; Flammable Gas

- **Appearance and odor**

  Cyanogen is a highly flammable, colorless gas with a pungent, penetrating, almond-like odor; this substance is shipped as a liquefied gas under its own vapor pressure. The odor threshold is reported to be 250 parts per million (ppm) parts of air.

CHEMICAL AND PHYSICAL PROPERTIES

- **Physical data**

  1. Molecular weight: 52.04
  2. Boiling point (760 mm Hg): -21.17°C (-6.1°F)
  3. Specific gravity (for the liquid) (water = 1): 0.95 at 20°C (68°F)
  4. Vapor density (air = 1 at boiling point of cyanogen): 1.8
  5. Melting point: -27.9°C (-18.2°F)
  6. Vapor pressure at 21°C (69.9°F): 3,868.4 mm Hg
  7. Solubility: Soluble in water, alcohol, and ether
  8. Evaporation rate: Not applicable

- **Reactivity**

  1. Conditions contributing to instability: Heat, sparks, open flame, shock, and direct sunlight

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2. Incompatibilities: Contact of cyanogen with acids or their vapors, water, liquid oxygen, or oxidizers (such as chlorine, fluorine, or bromine) causes explosions.

3. Hazardous decomposition products: Toxic gases and vapors (such as cyanide, hydrogen cyanide, carbon monoxide, and oxides of nitrogen) may be released in a fire involving cyanogen.

4. Special precautions: Cyanogen is denser than air and can collect in enclosed spaces. It can flow along the surface, reach distant, low-lying sources of ignition, and flash back.

Flammability

The National Fire Protection Association has assigned a flammability rating of 4 (extreme fire hazard) to cyanogen.

1. Flash point: Cyanogen has a wide range of explosiveness.

2. Autoignition temperature: Data not available

3. Flammable limits in air (% by volume): Lower, 6.6; upper, 32

4. Extinguishant: Let the fire burn unless the leak can be stopped immediately. Use water spray, fog, or standard foam to fight large fires involving cyanogen. Water may be used to cool fire-exposed containers and to protect persons attempting to stop the leak.

Fires involving cyanogen should be fought upwind from the maximum distance possible. Isolate the hazard area and deny access to unnecessary personnel. Emergency personnel should stay out of low areas and ventilate closed spaces before entering. Cyanogen is heavier than air and may travel to a source of ignition and flash back. Containers of cyanogen may explode in the heat of the fire and should be moved from the fire area if it is possible to do so safely. If this is not possible, cool containers from the sides with water until well after the fire is out. Stay away from the ends of containers. Personnel should withdraw immediately if they hear a rising sound from a venting safety device or if a container becomes discolored as a result of fire. If a tank car or truck is involved in a fire, personnel should isolate an area of a half mile in all directions. Firefighters should wear a full set of protective clothing and self-contained breathing apparatus when fighting fires involving cyanogen. Chemical protective clothing that is specifically recommended for cyanogen may not provide thermal protection unless so stated by the clothing manufacturer. Structural firefighters' protective clothing may provide limited protection against fires involving cyanogen.

EXPOSURE LIMITS

- **OSHA PEL**

The Occupational Safety and Health Administration (OSHA) has not promulgated a permissible exposure limit (PEL) for cyanogen [29 CFR 1910.1000, Table Z-1].

- **NIOSH REL**

The National Institute for Occupational Safety and Health (NIOSH) has established a recommended exposure limit (REL) of 10 ppm (20 mg/m^3) as a TWA for up to a 10-hr workday and a 40-hr workweek [NIOSH 1992].

- **ACGIH TLV**

The American Conference of Governmental Industrial Hygienists (ACGIH) has assigned cyanogen a threshold limit value (TLV) of 10 ppm (21 mg/m^3) as a TWA for a normal 8-hr workday and a 40-hr workweek [ACGIH 1993].

- **Rationale for limits**

The NIOSH limit is based on the risk of eye and respiratory irritation associated with cyanogen exposure. The ACGIH limit is based on the risk of irritant and systemic effects associated with exposure to cyanogen.

HEALTH HAZARD INFORMATION

- **Routes of exposure**

Exposure to cyanogen can occur through inhalation and eye or skin contact.

- **Summary of toxicology**

1. *Effects on Animals:* Cyanogen is a highly toxic gas that causes severe irritation, respiratory distress, and death on acute exposure. Rabbits survived dermal exposure to 10,000 ppm for 8 hours without apparent systemic effects [McNerney and Schrenk 1960]. The

LC_{50} in rats is 350 ppm for 1 hr [NIOSH 1990]. Acutely poisoned animals showed signs of respiratory distress and severe eye irritation before death [NIOSH 1990]. Monkeys and rats exposed for 6 hr/day, 5 days/week to 11 or 25 ppm of cyanogen for 6 months showed no hematologic, clinical, or histopathological changes attributable to exposure [NLM 1992].

2. *Effects on Humans:* Cyanogen causes cellular hypoxia in humans; in lethal amounts, it causes respiratory and central nervous system stimulation, followed by headache, vertigo, agitation followed by combative behavior, coma, convulsions, respiratory arrest, and death [NLM 1992]. Cyanogen reacts readily with cytochrome oxidase in mitochondria which inhibits tissue oxidation resulting in cytotoxic hypoxia. In addition to hypoxia, exposure to cyanogen causes eye, nose, and upper respiratory tract irritation. Exposure to a concentration of 16 ppm for 6 to 8 min caused irritation, but exposure to 8 ppm for the same interval caused no irritation [McNerney and Schrenk 1960].

- **Signs and symptoms of exposure**

1. *Acute exposure:* Acute exposure to cyanogen may cause pain, redness, and tearing of the eyes, runny nose, and difficult breathing; if the overexposure is severe, the following signs of cyanide poisoning are seen: cherry red lips, tachypnea and hyperpnea (followed by bradycardia), headache, vertigo, agitation, behavioral changes, and convulsions.

2. *Chronic exposure:* The signs and symptoms of chronic overexposure to cyanogen include those of thyroid dysfunction: dizziness, loss of appetite, and weight loss.

- **Emergency procedures**

> **WARNING!**
>
> **Seek immediate medical attention for severely affected victims or for victims with signs and symptoms of toxicity or irritation!**

Keep unconscious victims warm and on their sides to avoid choking if vomiting occurs. Initiate the following emergency procedures:

1. *Eye exposure:* Irritation may result. ***Immediately and thoroughly*** flush the eyes with large amounts of water, occasionally lifting the upper and lower eyelids.

2. *Skin exposure:* Irritation may result. ***Thoroughly*** wash contaminated skin with soap and water.

3. *Inhalation exposure:* Move the victim to fresh air ***immediately.***

   If the victim is not breathing, clean any chemical contamination from the victim's lips and perform cardiopulmonary resuscitation (CPR); if breathing is difficult, give oxygen.

4. *Rescue:* Remove an incapacitated worker from further exposure and implement appropriate emergency procedures (e.g., those listed on the material safety data sheet required by OSHA's hazard communication standard [29 CFR 1910.1200]). All workers should be familiar with emergency procedures and the location and proper use of emergency equipment.

EXPOSURE SOURCES AND CONTROL

The following operations may involve cyanogen and may result in worker exposures to this substance:

—Use as an intermediate in organic synthesis

—Use as a fumigant

—Use for welding and cutting heat-resistant metals

—Use as a rocket and missile propellant

The following methods are effective in controlling worker exposures to cyanogen, depending on the feasibility of implementation:

—Process enclosure

—Local exhaust ventilation

—General dilution ventilation

—Personal protective equipment

Good sources of information about control methods are as follows:

1. ACGIH [1992]. Industrial ventilation—a manual of recommended practice. 21st ed. Cincinnati, OH: American Conference of Governmental Industrial Hygienists.

2. Burton DJ [1986]. Industrial ventilation—a self study companion. Cincinnati, OH: American Conference of Governmental Industrial Hygienists.

3. Alden JL, Kane JM [1982]. Design of industrial ventilation systems. New York, NY: Industrial Press, Inc.

4. Wadden RA, Scheff PA [1987]. Engineering design for control of workplace hazards. New York, NY: McGraw-Hill.

5. Plog BA [1988]. Fundamentals of industrial hygiene. Chicago, IL: National Safety Council.

MEDICAL MONITORING

Workers who may be exposed to chemical hazards should be monitored in a systematic program of medical surveillance that is intended to prevent occupational injury and disease. The program should include education of employers and workers about work-related hazards, early detection of adverse health effects, and referral of workers for diagnosis and treatment. The occurrence of disease or other work-related adverse health effects should prompt immediate evaluation of primary preventive measures (e.g., industrial hygiene monitoring, engineering controls, and personal protective equipment). A medical monitoring program is intended to supplement, not replace, such measures. To place workers effectively and to detect and control work-related health effects, medical evaluations should be performed (1) before job placement, (2) periodically during the term of employment, and (3) at the time of job transfer or termination.

- **Preplacement medical evaluation**

Before a worker is placed in a job with a potential for exposure to cyanogen, a licensed health care professional should evaluate and document the worker's baseline health status with thorough medical, environmental, and occupational histories, a physical examination, and physiologic and laboratory tests appropriate for the anticipated occupational risks. These should concentrate on the function and integrity of the respiratory system and thyroid.

A preplacement medical evaluation is recommended to detect and assess medical conditions that may be aggravated or may result in increased risk when a worker is exposed to cyanogen at or below the prescribed exposure limit. The licensed health care professional should consider the probable frequency, intensity, and duration of exposure as well as the nature and degree of any applicable medical condition. Such conditions (which should not be regarded as absolute contraindications to job placement) include a history and other findings consistent with diseases of the respiratory system or thyroid.

- **Periodic medical examinations and biological monitoring**

Occupational health interviews and physical examinations should be performed at regular intervals during the employment period, as mandated by any applicable Federal, State, or local standard. Where no standard exists and the hazard is minimal, evaluations should be conducted every 3 to 5 years or as frequently as recommended by an experienced occupational health physician. Additional examinations may be necessary if a worker develops symptoms attributable to cyanogen exposure. The interviews, examinations, and medical screening tests should focus on identifying the adverse effects of cyanogen on the respiratory system or thyroid. Current health status should be compared with the baseline health status of the individual worker or with expected values for a suitable reference population.

Biological monitoring involves sampling and analyzing body tissues or fluids to provide an index of exposure to a toxic substance or metabolite. Thiocyanate, a metabolite of cyanide, can be measured in the plasma and urine of exposed individuals. However, the levels of thiocyanate in these body fluids that correspond to airborne concentrations of cyanogen have not been determined. Therefore, no biological monitoring test acceptable for routine use has yet been developed for cyanogen.

- **Medical examinations recommended at the time of job transfer or termination**

The medical, environmental, and occupational history interviews, the physical examination, and selected physiologic or laboratory tests that were conducted at the time of placement should be repeated at the time of job transfer or termination. Any changes in the worker's health status should be compared with those expected for a suitable reference population.

WORKPLACE MONITORING AND MEASUREMENT

A worker's exposure to airborne cyanogen is determined

by using a coated XAD-2 tube (150/75-mg sections, 20/60 mesh) coated with 10% (w/w) 2-(hydroxymethyl) piperidine. Samples are collected at a maximum flow rate of 0.2 liter/min until a maximum air volume of 12 liters is collected. Analysis is conducted by gas chromatography using a nitrogen phosphorus detector. This method is included in the OSHA Laboratory In-House Methods File [OSHA 1989].

PERSONAL HYGIENE

If cyanogen contacts the skin, workers should immediately wash the affected areas with soap and water.

Clothing contaminated with cyanogen should be removed immediately.

A worker who handles cyanogen should thoroughly wash hands, forearms, and face with soap and water before eating, using tobacco products, using toilet facilities, or applying cosmetics.

Workers should not eat, drink, use tobacco products, or apply cosmetics in areas where cyanogen is handled, processed, or stored.

STORAGE

Cyanogen should be stored in pressurized, secured, airtight containers in a cool, dry, well-ventilated area; the containers must be labeled in accordance with OSHA's hazard communication standard [29 CFR 1910.1200]. Storage areas must meet requirements for a Class I flammable liquid. Outside or detached storage is preferred; inside storage should be in a standard flammable liquids storage room. Ventilation systems used in cyanogen storage areas must be maximally explosion proof. Containers of cyanogen should be protected from physical damage and should be stored separately from water, acids, acid vapors, and oxidizers. Containers should also be protected from shock, direct sunlight, heat, sparks, and open flame. Drums must be equipped with self-closing valves, pressure vacuum bungs, and flame arresters. Only non sparking tools may be used to handle cyanogen. To prevent static sparks, containers should be grounded and bonded for transfers.

LEAKS

In the event of a leak involving cyanogen, persons not wearing protective equipment and clothing should be restricted from contaminated areas until cleanup is complete. The following steps should be undertaken following a leak:

1. Stop the leak if it is possible to do so without risk.
2. Notify safety personnel.
3. Remove all sources of heat and ignition.
4. Ventilate potentially explosive atmospheres.
5. Use water spray to reduce vapors; do not get water inside the container.

SPECIAL REQUIREMENTS

U.S. Environmental Protection Agency (EPA) requirements for emergency planning, reportable quantities of hazardous releases, community right-to-know, and hazardous waste management may change over time. Users are therefore advised to determine periodically whether new information is available.

- **Emergency planning requirements**

  Cyanogen is not subject to EPA emergency planning requirements under the Superfund Amendments and Reauthorization Act (SARA) [42 USC 11022].

- **Reportable quantity requirements for hazardous releases**

  A hazardous substance release is defined by EPA as any spilling, pumping, pouring, emitting, emptying, discharging, injecting, escaping, leaching, dumping, or disposing into the environment (including the abandonment or discarding of contaminated containers) of hazardous substances. In the event of a release that is above the reportable quantity for that chemical, employers are required by the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) [40 CFR 355.40] to notify the proper Federal authorities.

  The reportable quantity for cyanogen is 100 lb. If an amount equal to or greater than this quantity is released within a 24-hr period in a manner that will expose persons outside the facility, employers are required to do the following:

  —Notify the National Response Center ***immediately*** at (800) 424-8802 or at (202) 426-2675 in Washington, D.C. [40 CFR 302.6].

—Notify the emergency response commission of the State likely to be affected by the release [40 CFR 355.40].

—Notify the community emergency coordinator of the local emergency planning committee (or relevant local emergency response personnel) of any area likely to be affected by the release [40 CFR 355.40].

- **Community right-to-know requirements**

Employers who own or operate facilities in SIC codes 20 to 39, who employ 10 or more workers, and who manufacture 25,000 lb or more or otherwise use 10,000 lb or more of cyanogen per calendar year are required by EPA to submit a Toxic Chemical Release Inventory Form (Form R) to EPA [49 CFR 372.30] reporting the amount of cyanogen emitted or released from their facility annually.

- **Hazardous waste management requirements**

EPA considers a waste to be hazardous if it exhibits any of the following characteristics: ignitability, corrosivity, reactivity, or toxicity as defined in 40 CFR 261.21-261.24. Cyanogen is listed as a hazardous waste under the Resource Conservation and Recovery Act (RCRA) [42 USC 6901 et seq.], and has been assigned EPA Hazardous Waste No. P031. This substance has been banned from land disposal and may be treated by chemical oxidation, wet air oxidation, or incineration. Cyanogen also may be disposed of in an organometallic or organic lab pack that meets the requirements of 40 CFR 264.316 or 265.316.

Providing detailed information about the removal and disposal of specific chemicals is beyond the scope of this guideline. The U.S. Department of Transportation, EPA, and State and local regulations should be followed to ensure that removal, transport, and disposal of this substance are conducted in accordance with existing regulations. To be certain that chemical waste disposal meets EPA regulatory requirements, employers should address any questions to the RCRA hotline at (800) 424-9346 or at (202) 382-3000 in Washington, D.C. In addition, relevant State and local authorities should be contacted for information about their requirements for waste removal and disposal.

RESPIRATORY PROTECTION

- **Conditions for respirator use**

Good industrial hygiene practice requires that engineering controls be used where feasible to reduce workplace concentrations of hazardous materials to the prescribed exposure limit. However, some situations may require the use of respirators to control exposure. Respirators must be worn if the ambient concentration of cyanogen exceeds prescribed exposure limits. Respirators may be used (1) before engineering controls have been installed, (2) during work operations such as maintenance or repair activities that involve unknown exposures, (3) during operations that require entry into tanks or closed vessels, and (4) during emergencies. Workers should use only respirators that have been approved by NIOSH and the Mine Safety and Health Administration (MSHA).

- **Respiratory protection program**

Employers should institute a complete respiratory protection program that, at a minimum, complies with the requirements of OSHA's respiratory protection standard [29 CFR 1910.134]. Such a program must include respirator selection, an evaluation of the worker's ability to perform the work while wearing a respirator, the regular training of personnel, respirator fit testing, periodic workplace monitoring, and regular respirator maintenance, inspection, and cleaning. The implementation of an adequate respiratory protection program (including selection of the correct respirator) requires that a knowledgeable person be in charge of the program and that the program be evaluated regularly. For additional information about the selection and use of respirators and about the medical screening of respirator users, consult the *NIOSH Respirator Decision Logic* [NIOSH 1987b] and the *NIOSH Guide to Industrial Respiratory Protection* [NIOSH 1987a].

PERSONAL PROTECTIVE EQUIPMENT

Protective clothing (gloves, boots, aprons, and full-body clothing, as appropriate) should be worn to prevent any skin contact with liquid cyanogen. Chemical protective clothing should be selected on the basis of available performance data, manufacturers' recommendations, and evaluation of the clothing under actual conditions of use. No reports have been published on the resistance of various protective clothing materials to cyanogen permeation. If permeability data are not readily available, protective clothing manufacturers should be requested to provide information on the best chemical protective clothing for workers to wear when they are exposed to cyanogen.

Safety glasses, goggles, or face shields should be worn during operations in which cyanogen might contact the eyes. Eyewash fountains and emergency showers should

be available within the immediate work area whenever the potential exists for eye or skin contact with cyanogen. Contact lenses should not be worn if the potential exists for cyanogen exposure.

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